

Final Exam (2020-2021) – Population Dynamics Models

Submit by **September 10, 2021**. Write up your exam as a <2500 words manuscript with a well sourced introduction, methods, and use task 1-3 to write your "results" and "discussion". Add a Title, short abstract, references, and an appendix that includes your annotated R script.

Data

Consider the following 2×2 projection matrix \mathbf{A} which represent the demographic transitions for a subshrub plant species. We will use this matrix to illustrate the role of semelparity, delayed reproduction and density dependence on population dynamics.

$$\mathbf{A} = \begin{bmatrix} \sigma_1(1 - \gamma) & \phi \\ \sigma_1\gamma & \sigma_2 \end{bmatrix}$$

In the matrix \mathbf{A} , γ is bounded between zero and one and describe the maturation process. Species for which γ has large values are characterized by rapid maturation process (precocious development). In contrast, species with small values for γ have slow maturation process and therefore delay reproduction. σ_2 is also bounded between zero and one and represent the survival rate of adult reproductive individuals. Consequently, species with small values of σ_2 tend to be semelparous because in this case adults are less likely to reproduce more than once given their low survival probability. However, species with large σ_2 have long-lived adults and are therefore iteroparous. ϕ represent the fertility, the mean number of offspring produced by adults.

Task 1 - 30pts

Suppose that $\sigma_1 = 0.5$, $\sigma_2 = 0.9$, and $\phi = 1.5$. Using matrix \mathbf{A} simulate the effects of delayed reproduction on the asymptotic (λ_0) and transient (λ_1) dynamics of the study species. Append your script in the appendix (10pts). Show illustrative figures (10pts), report and interpret your results (10pts).

Task 2 - 40pts

Now, suppose that $\sigma_1 = 0.5$, $\gamma = 0.1$, and $\phi = 1.5$. Using matrix \mathbf{A} simulate the effects of iteroparity on the asymptotic and transient dynamics of the study species. Append your script in the appendix (10pts). Show illustrative figures (10pts), report and interpret your results (10pts). Can semelparity life history be selected for? That is, is semelparity an evolutionary persistent trait? (10pts)

Task 3 - 30pts

Negative density dependence is an important process that can alter population dynamics. Density dependent projection matrix are written as a function of the total population size N : $\mathbf{A}(N)$. Density dependence is often modeled using Beverton Holt function ($\frac{1}{1+N}$) to capture compensatory density dependence and Ricker function (e^{-N}) to illustrate over-compensatory density dependence. Assuming that density dependence affects only fertility ϕ , use \mathbf{A} ($\sigma_1 = 0.5$, $\gamma = 0.1$, and $\phi = 1.5$) to simulate the effect of over-compensatory density dependence on the asymptotic and transient population dynamics for semelparous ($\sigma_2 = 0.1$) and iteroparous ($\sigma_2 = 0.9$) species. Append your script in the appendix (10pts). Show illustrative figures (10pts), report and interpret your results (10pts).